NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

DIKE

(Ft.)

CODE 356

DEFINITION

An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

PURPOSE

To permit improvement of agricultural land by preventing overflow and better use of drainage facilities, to prevent damage to land and property, and to facilitate water storage and control in connection with wildlife and other developments. Dikes can also be used to protect natural areas, scenic features, and archeological sites from damage.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to dikes or levees used to prevent or reduce flood damage to land and property, for flow control in conjunction with floodways, or to impound or regulate water for fish and wildlife management.

Dikes are divided into classes determined by the value of the land, crops, and other improvements and the hazard to life within the area to be protected.

Class I dikes are those constructed on sites where:

1. Failure may cause loss of life or serious damage to homes; industrial and commercial buildings; important public utilities; main highways or railroads; and high value land, crops, or other improvements.
2. Unusual or complex site conditions require special construction procedures to ensure satisfactory installations.
3. Protection is needed to withstand more than 12 feet of water above normal ground surface (exclusive of crossing of sloughs, old channels, or low areas).

Class II dikes are those constructed in highly developed and productive agricultural areas where:

1. Failure may damage isolated homes, highways, or minor railroads or cause interruption in service of relatively important public utilities.
2. The maximum design water stage against the dike is 12 feet.

Class III dikes are those constructed in rural or agricultural areas where:

1. Damage likely to occur from dike failure is minimal.
2. The maximum design water stage against the dike is 6 feet for mineral soils and 4 feet for organic soils. (Exclude channels, sloughs, swales, and gullies in determining the design water stage.)

CRITERIA

General Criteria Applicable to All Purposes

Laws, rules, and regulations. This practice shall conform to all federal, state, and local laws, rules, and regulations. Laws, rules, and regulations of particular concern include those involving water rights, land use, pollution control, property easements, wetlands, preservation of cultural resources, and endangered species.

The owner is responsible for securing necessary permits, complying with all laws and regulations,

and meeting legal requirements applicable to the installation and operation and maintenance of the dike and associated structures.

In locating dikes, careful consideration shall be given to preserving natural areas, fish and wildlife habitat, woodland, and other environmental resources. If dike construction will adversely affect such factors, concerned public agencies and private organizations shall be consulted about the project.

Protection. A protective cover of grasses shall be established on all exposed surfaces of the dike and other disturbed areas. Seedbed preparation, seeding, fertilizing, mulching, and fencing shall comply with Conservation Practice Standards 342, Critical Area Planting; and 382, Fencing.

If vegetation will not control erosion, riprap or other protective measures shall be installed.

Maintenance. All dikes must be adequately maintained to the required shape and height. The maintenance of dikes must include periodic removal of woody vegetation that may become established on the embankment. Provisions for maintenance access must be provided.

Design Criteria - Class I Dikes

Location. Conditions to be considered in designing Class I dikes are foundation soils, property lines, exposure to open water, adequate outlets for gravity or pump drainage, and access for construction and maintenance. Mineral soils that will be stable in the dike embankment must be available.

Height. The design height of a dike shall be the design high water depth plus 2 feet of freeboard or 1 foot of freeboard plus an allowance for wave height, whichever is greater. Design elevation of high water shall be determined as follows:

1. If dike failure is likely to cause loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the stage of the 100-year-frequency flood or of the maximum flood of record, whichever is greater.
2. If dike failure is unlikely to result in loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the peak flow from the storm that will ensure the desired level of protection or the 50-year-frequency flood, whichever is greater.
3. If the dike will be subject to stages from more than one stream or source, the criteria indicated should be met for the combination that causes the highest stage.

The design height of the dike shall be increased by the amount needed to ensure that the design top elevation is maintained after settlement. This increase shall not be less than 5 percent.

Interior drainage. If inflow from the area to be protected by the dike may result in loss of life or extensive high-value crop property damage, provisions shall be included in the plans to provide interior protection against a 100-year-frequency hydrograph (plus base flow) and an allowance for seepage and may include storage areas, gravity outlets, or pumping plants (alone or in combination).

If inflow from the area to be protected by the dike is unlikely to result in loss of life or extensive high-value crop or property damage, storage areas, gravity outlets, or a pumping plant (alone or in combination) shall be included in the plans and designed to handle the discharge from the drainage area based on drainage requirements established for the local area or the peak flow from the storm that will ensure the desired level of protection, whichever is greater.

In sizing outlet works in combination with available storage, the minimum design storm duration for interior drainage shall be 10 days. If outlet works are designed using peak flood frequency flows without considering storage, the minimum design storm duration shall be 24 hours.

Embankment and foundation. The embankment shall be constructed of mineral soils, which (when placed and compacted) will result in a stable earthfill. No organic soil shall be used in the dike. Soils must have high specific gravity and be capable of being formed into an embankment of low permeability. The design of the embankment and specifications for its construction shall give due consideration to the soil materials available, foundation conditions, and requirements for resisting the action of water on the face of the dike and excessive seepage through the embankment

and the foundation. The design of the embankment and the foundation requirements shall be based on the length of time and height that water will stand against the dike.

Minimum requirements for certain features of the embankment, the foundation, and borrow pits are as follows:

Minimum top width of Class I dikes shall be 10 feet for embankment heights of 15 feet or less and 12 feet for heights more than 15 feet. If maintenance roads are to be established on the dike top, "turnarounds" or passing areas shall be provided, as needed.

Side slopes shall be determined from a stability analysis, except that an unprotected earth slope on the waterside shall not be steeper than 4 horizontal to 1 vertical (4:1) if severe wave action is anticipated.

If dikes cross old channels or have excessively porous fills or poor foundation conditions, the landside toe shall be protected by a banquette or constructed berm. Banquettes shall be used to provide construction access and added stability if channel crossings are under water or saturated during construction. Banquettes shall be designed on the basis of site investigations, laboratory analysis, and compaction methods. The finished top width of the banquettes shall not be less than the height of dike above mean ground. The finished top of the banquettes shall not be less than 1 foot above mean ground and shall be sloped away from the dike.

Foundation Cutoff. A foundation cutoff (or core trench) shall be used if foundation materials are sufficiently pervious to be subject to piping or undermining. The cutoff shall have a bottom width and side slopes adequate to accommodate the equipment to be used for excavation, backfill, and compaction operations. It shall be backfilled with suitable material placed and compacted as required for the earth embankment. If previous foundations are too deep to be penetrated by a foundation cutoff, a drainage system adequate to ensure stability of the dike shall be used.

Ditches and borrow pits. Landside ditches or borrow pits shall be located so the hazard of failure is not increased. Ditches for borrow pits (when excavated on the water side of dikes) shall be wide and shallow. Plugs, at least 15 feet in width, shall be left in the ditches at intervals not greater than 400 feet to form a series of unconnected basins.

Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be as shown below:

Fill Height	Minimum Berm Width
Less than 6 feet	12 feet
More than 6 feet	18 feet

A drainage system shall be used if necessary to ensure the safety of a dike. Toe drains, if used, shall be located on the landside and shall have a graded sand-gravel filter designed to prevent movement of the foundation material into the drain.

Subsurface drains shall not be installed (or permitted to remain without protection) closer to the landside toe of a dike than a distance 3 times the design water height for the dike. If subsurface drains are to be installed or remain closer than the distance stated, protection shall consist of a graded sand-gravel filter (as for a toe drain) or a closed pipe laid within the specified distance from the dike.

Pipes and conduits. Dikes shall be protected from scour at pump intakes and discharge locations by appropriate structural measures. A pump discharge pipe through a dike shall be installed above design high water, if feasible, or be equipped with anti-seep collars.

All conduits through a dike below the design high waterline shall be equipped with anti-seep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed water line shall be equipped with a Dayton or similar coupling to prevent vibration of the pumping plant being transmitted to the discharge conduits.

Design Criteria - Class II Dikes

Design water stage. The maximum design water stage permitted is 12 feet above normal ground level exclusive of crossings at channels, sloughs, and gullies.

If the design water depth against dikes (based on the required level of protection) exceeds 4 feet, the design shall be based on at least a 25-year-frequency flood. If this degree of protection is not feasible, the design shall

approach the 25-year flood level as nearly as possible, and planned fuse plug sections and other relief measures shall be installed where appropriate.

Height. The design height of an earth dike shall be the design water depth plus a freeboard of at least 2 feet or a freeboard of 1 foot plus an allowance for wave height, whichever is greater.

The constructed height of the dike shall be the design height plus allowance for settlement necessary to ensure that the design top elevation is maintained but shall be no less than 5 percent of the design height.

Embankment. The fill material shall be free of organic matter, debris, and other objectionable material. It should be spread in horizontal layers that do not exceed a depth of 9 inches. Where borrow yields material of varying texture and gradation, the more impervious material shall be placed toward the water side of the fill. Fill material should have sufficient moisture for adequate compaction. The construction equipment should be operated over the area of each layer of fill to break up large clods and obtain the desired compaction.

Interior drainage. Provisions must be made for adequate drainage for the area to be protected by the dike.

Cross section. The minimum requirements for the cross section of the dike where fill is compacted by hauling or special equipment shall be as shown in the following table:

Design Water Height (feet)	Minimum Top Width (feet)	Steepest Side Slope
0-10	8	2:1
10-12	10	2:1

If soils or water conditions make it impractical to compact the dike with hauling or special equipment, dumped fill may be used and shall have minimum cross section dimensions incorporated in the fill as shown in the following table:

Design Water Height (feet)	Minimum Top Width (feet)	Steepest Side Slope
0-6	8	2:1
6-10	8	2½:1
10-12	10	2½:1

Side slopes of 3:1 on waterside and 2:1 on landside may be used instead of 2½:1 for both slopes.

The cross sections shall be strengthened or increased as required to provide additional protection against floods of long duration. The top width shall be less than 10 feet if a maintenance road is planned on top of the dike. Turnarounds (or passing areas) shall be provided as required on long dikes.

The side slopes shall be 3:1 or flatter on the waterside if severe wave action is expected or if a steeper slope would be unstable under rapid drawdown conditions. Side slopes shall be 3:1 or flatter on both sides where permeable soils of low plasticity, such as SM and ML, are used in construction.

A banquette (or constructed berm) shall reinforce the landside toe if a dike crosses an old channel or if excessively porous fill or poor foundation conditions justify such reinforcement. Such banquettes shall be used if, during construction, the channel crossing is under water or saturated. The top width of the banquette shall be equal to or greater than the fill height of the dike above the top of the banquette unless a detailed investigation and analysis show a different design is adequate.

Foundation Cutoff. A foundation cutoff (or core trench) shall be installed if there are layers of permeable soils or layers creating a piping hazard through the foundation at a depth less than the design water depth of the dike below natural ground level. The cutoff trench shall be of sufficient depth and width and filled with suitable soils to minimize such hazard.

Ditches and borrow pits. Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be as shown below:

Fill Height	Minimum Berm Width
Less than 6 feet	10 feet
More than 6 feet	15 feet

A landside ditch or borrow pit shall be far enough away from the dike to minimize any hazard to the dike because of piping through the foundation.

For dikes having a design water depth of more than 5 feet, the landside ditch or borrow pit shall

be far enough away from the dike so that a line drawn between the point of intersection of the design waterline with the waterside of the dike and the landside toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

Pipes and conduits. The dike shall be protected from scour at a pump intake and discharge by appropriate structural measures. A pump discharge pipe through the dike shall be installed above design high water, if feasible, or else equipped with anti-seep collars.

All conduits through the dike below the design high waterline shall be equipped with anti-seep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed waterline shall be equipped with a Dayton or similar coupling to prevent vibration of the pumping plant being transmitted to the discharge conduits.

Drains. Drains shall be used where necessary to ensure the safety of dikes. They shall be located on the landside and have a graded sand-gravel filter.

Field subsurface drains shall not be installed (or permitted to remain without protection) closer to the landside toe of a dike than a distance 3 times the design water height for the dike. If such drains are to be installed or remain closer than the distance stated above, protection shall consist of a graded sand-gravel filter (as for a toe drain) or a closed pipe laid within the specified distance from the dike.

Design Criteria - Class III Dikes

The design criteria shall be based on soil and site conditions as determined from engineering surveys and investigations.

Design water stage. Dikes of this class shall provide protection for at least a 10-year flood level.

Cross section. Design top width will not be less than 8 feet, and side slopes will not be steeper than 2:1.

Freeboard. The top of the dike shall be at or above the flow depth of the 10-year storm through the vegetative spillway or 1 foot above the wave height calculated at the permanent pool level (whichever is greater). The constructed height shall be increased by the amount necessary to ensure that the settled top is at or above design elevation but not less than 5 percent.

Foundation Cutoff. A foundation cutoff (or core trench) shall be installed, if necessary, to ensure dike stability.

Embankment. Dikes constructed from channel spoil may be shaped to approximate cross section. However, the spoil must be shaped to meet the designed cross section plus settlement and left so that sloughing and sliding will not impair this section.

Ditches and borrow pits. Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be 2 times the depth of the ditch but not less than 8 feet.

CONSIDERATIONS

Water quantity concerns include the following:

1. Effects upon components of the water budget, especially on volumes and rates of runoff, infiltration, evaporation, and transpiration
2. Potential for changes in rates of plant growth and transpiration because of changes in the volume of soil water
3. Effects on downstream flows or aquifers that would affect other water uses or users
4. Effects on the rate or volume of downstream flow to prohibit environmental, social, or economic effects

Water quality concerns include the following:

1. Effect on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff
2. Effects on the movement of dissolved substances to ground water
3. Short-term, construction, and maintenance-related effects on the quality of water resources
4. Effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities

5. Effects on wetlands or water-related wildlife habitats that would be associated with the practice
6. Effects on the visual quality of water resources

PLANS AND SPECIFICATIONS

Plans and specifications for constructing dikes shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed and reviewed with the landowner or individual responsible for operation and maintenance. The plan should be consistent with the purposes of the practice, intended life, and the criteria for its design.